

Chapter X

Navigation in Computer Assisted Orthopaedic Surgery

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ABSTRACT

Originally developed for neurosurgery procedures, since late nineties Computer Assisted Surgery (CAS) systems have been used in orthopaedic interventions. Such systems assist the surgeon during the pre-operative or the intra-operative planning phase from diagnostic data, during the intra-operative phases of registration and navigation. They provide quantitative information of the overall surgical outcome and allow controlling range of accuracy and repeatability. Despite recognized advance in introducing the computer in the orthopaedic operative room (OR), several aspects are still debated such as operative time prolongation, information provided to the surgeon and user interface management. The chapter is aimed at reviewing main navigation systems as far as the visual and interactive aspects are concerned and at suggesting useful tools in order to enhance the surgeon usability of a navigation system. We developed modules for Total Knee Replacement (TKR) and Total Hip Replacement (THR), named KneeLab and HipLab respectively. In the two applications, we coped with two main aspects of the navigation in knee and hip replacement combining new visualization methods and new working methods. In the chapter, the reader can find a detailed description of the solution proposed to overcome problems commonly found with navigation systems in orthopaedics. We introduced innovative methods and algorithms, new modality of vocal interface, fully 3D graphics, recovery session from file system. The development aimed at the fulfilment of the critical user requirements of the operating room, by providing the user with a tightly guided procedure and an immediate graphical virtual environment.

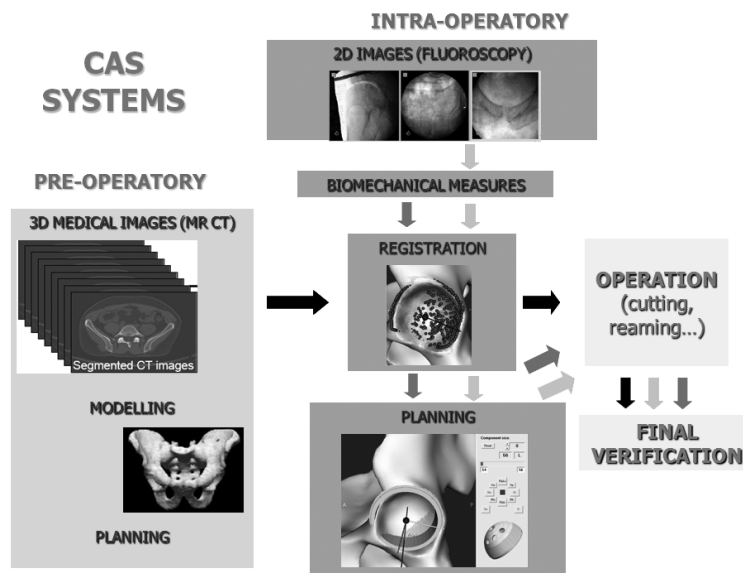
INTRODUCTION

Computer Assisted Surgery (CAS), also known as navigated surgery, refers to computer-enabled technologies including medical robotics, image guided surgery, computer-integrated advanced orthopaedics, stereotactic guidance and computer assisted medical interventions. Any CAS system is principally aimed at providing quantitative evaluation of single operation acts and of the overall surgical outcome. Secondly, surgeons can take advantage by the use of assistive instruments integrated in or even monitored and controlled by the CAS system. Thirdly, measurements and surgical evaluations are provided within controlled range of accuracy and repeatability. Besides enhancing the accuracy and the repeatability, CAS systems improve surgeon’s 3D perception of the surgical scenario and surgeon’s skill in performing highly demanding procedures (Martelli, 2003). All these features improve surgical performance and clinical outcomes (Delp, 1998). In general, non-contact

measure technologies, real-time computer feedback and augmented 3D visualization constitute the main facilities within CAS systems. In particular, 3D localization equipments (exploiting different physical principles as electromagnetic fields or video camera-based sensors) are utilized to obtain the intra-operative registration of the surgical site with the pre-operative diagnostic data. In addition, such equipments allow measuring indirectly the position and orientation of surgical instruments, implants and anatomical regions by directly tracking small rigid bodies are attached to them (Jaramaz, 1998; Zheng, 2002; Tria, 2006). The great advantage of such equipments rests in the ability to get measurements in real-time within a sufficient range of acquisition frequency which allows the acquisition of location of surgical instruments in motion.

The most general approach of CAS systems includes first a pre-operative step where diagnostic data are used to indicate the surgical planning (Figure 1). CAS systems can assist the surgeon

Figure 1. Typical CAS system flowchart



Coloured arrows indicate possibility of intervention (black arrows is the path followed in case of pre-operative planning availability, light gray arrows indicate the intra-operative images acquisition while dark gray arrows indicate the image-free navigation modality).

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